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separated by about 10 cm. of sand containing sherds of Sacaton Red-on-buff. The silt which filled the uppermost canal, however, contained no pottery.

From these clues it becomes possible to say that, although the third and latest canal was constructed during the Sacaton Phase of the Sedentary Period, probably before 1100 A. D., it may well have been used up into more recent times, even to the Classic Period, since settlements of this period lay to the west of Snaketown which itself was not then occupied.

This suspicion was confirmed by the results of the test made at the fork in the canal west of Snaketown towards the Classic settlements. Here there was no evidence of the two lower canals, suggesting that originally the system did not extend beyond Snaketown, and that only in late times was the upper canal carried westward to supply the new villages. Of greatest importance were waterworn sherds of Casa Grande Red-on-buff of the Classic Period in the beds of the canals, indicating strongly that they were in use when this type of pottery was being made. From this it may be concluded that the upper canal in Test 1, constructed in the Sacaton Phase of the Sedentary Period, was carrying water during the Classic Period, and that its extension was picked up in the test at the fork. In terms of the Christian calendar, 1300 A. D. would probably mark the end of the life of this latest canal.

Estimated conservatively, the Snaketown canal and its various renewals were used for a period of not less than 500 years; i. e. 800 to 1300 A. D. Canal irrigation as possessed by the Hohokam may well exceed this period, however, since the oldest canal in the Snaketown series was certainly not the first attempt at irrigation, it being in no way inferior to those of later times. How far into antiquity the beginning can be projected will be disclosed only by further study, but it can be asserted with assurance that, more than a thousand years ago, canal irrigation was already well entrenched in southern Arizona, and that from roughly 1200 to 1400 A. D. the canal systems attained their peak both as to gross size and aggregate mileage.

## VII.

A SUMMARY OF DATA ON ABORIGINAL COTTON  
OF THE SOUTHWESTVOLNEY H. JONES<sup>1</sup>

In pre-Columbian times the cultivated plants of the Old and the New Worlds were, on the whole, quite distinct. The only important group of domesticated plants occurring in both was the cottons. However, different species were cultivated in the two hemispheres.

Wissler (78, p. 43) outlines the cotton-belt of the New World as extending from the Pueblo region of the Southwest, through Mexico, and into Peru. Cotton was the principal textile fiber throughout this region. It was grown and used to a lesser extent in other parts of South America and the Antilles. He points out that this distribution was, in the main, coincident with the regions of higher culture, and considers (78, p. 47) the cotton complex in this hemisphere to have been essentially one and to have been diffused from a single center.

In view of the wide distribution of cotton in the Southwest and its important bearing on certain anthropological problems of that region, an examination of literature and material relative to the various phases of cotton cultivation and use in the region has been made. A brief summary of the results is given here.

The earliest written accounts of cotton in the Southwest are found in the chronicles of the early Spanish expeditions. These, almost without exception, mention the wearing of cotton clothing by Indians of the various pueblos and sometimes refer to fields of cotton.

For the Rio Grande valley and adjacent pueblos, the Piro and the Tigheux are mentioned most frequently as cultivating cotton.<sup>2</sup> Cultivation is also specified for Santo Domingo (55, pp. 98-99) and Acoma (15, p. 560; 66 p. 570), and the region around Chama (80, p. 44). Apparently cotton was not cultivated at Taos and Pecos (65, p. 575). It seems that Baudelier's statement, made in 1890 (2, p. 345), that cotton was grown in the Rio Grande valley as far north as Santo Domingo and Cochiti and that the people of the northern pueblos dressed chiefly in skins supplemented by cotton cloth, is still tenable.

Evidently the wearing of cotton *wanats* was general throughout the Rio Grande region, yet they do not seem to have been very plentiful. The people of Tigheux were unable to furnish Coronado with three

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2. Relacion del Suceso (65, p. 575); Jaramillo (44, p. 587); Mechem (53, pp. 273-276); Gallegos (27, pp. 262-265); Escalante (19, p. 165).

hundred pieces of cotton which he demanded (12, p. 495). The people of Acoma were said to trade cotton *munias* to the Querechos (20, p. 183). Cotton clothing and weaving were attributed to the Piro and Tigüex,<sup>3</sup> Keres (20, pp. 181-182), Tano (20, p. 180; 189), Pecos (20, p. 182; 12, p. 491; 42, p. 323), and Jemez (20, p. 182). Leves of cotton cloth were made upon the Indians around Santa Fe (5, p. 345).

The accounts for Zuni indicate that little, if any, cotton was grown there at the time of the early Spanish explorations. Cotton clothing was worn to some extent, apparently secured chiefly from the Hopi.<sup>4</sup>

All evidence points to considerable cultivation by the Hopi.<sup>5</sup> Cotton clothing seems to have been plentiful, as the members of Espejo's party reported that gifts of large amounts were made to them. Luxán (50, p. 101) says that Espejo and his men saw large fields of cotton.

Early data on the Gila region is scattered and fragmentary, but cultivation appears to have been intensive and cotton clothing common.<sup>6</sup> The industry seems to have been centered among the Pima, but the Maricopa and possibly the Papago also cultivated cotton.

Since the time of the Spanish explorations, the growing and use of aboriginal cotton has declined. The early introduction of sheep and the later availability of yarn and cloth at trading posts have doubtless been important factors causing the decline. Cultivation was languishing in the middle of the last century, and was practically extinct when serious anthropological work was begun in the region about 1890. The cultivation since that time has been chiefly in small plots for ceremonial purposes.

Cotton is known to still be rather generally used for ceremonial purposes in the Rio Grande pueblos, but otherwise little reference to it has been made in recent years. A specimen was collected in the vicinity of Española, New Mexico, by Mrs. Stevenson prior to 1912, but in the published account (49, p. 8), the date and the pueblo are not given. A Santa Clara man, who died in 1909, is said to have raised cotton (68, p. 103). Parsons says that cotton was still cultivated for ceremonial purposes at Jemez in 1922 (61, pp. 14-15), and at Isleta in 1925

3. Castañeda (12, pp. 495-521); Coronado (15, p. 583); Espejo (20, p. 177); Luxán (50, pp. 72-73); Escalante (19, pp. 155-156); Bustamante (11, pp. 146-147).  
4. Castañeda (12, p. 517); Coronado (15, pp. 558; 560-563); Relación Positiva de Sirova (66, p. 569); Jaramillo (44, p. 586); Relación del Suceso (65, p. 673); Mendoza (54, pp. 549-550); Espejo (20, p. 185); Luxán (50, pp. 89; 91); Bustamante (11, pp. 148-149); Zárate-Salmerón (80, p. 47); Oñate (60, p. 235); Baudelot (2, pp. 37; 157).

5. Castañeda (12, p. 459); Mendoza (54, p. 550); Coronado (15, p. 582); Relación del Suceso (65, p. 574); Jaramillo (44, p. 587); Luxán (50, pp. 98-102); Espejo (20, p. 185); Zárate-Salmerón (80, p. 84); Bustamante (11, p. 149); Escalante (19, p. 151); Garcés (28, p. 298); Fewkes (21, pp. 599; 629).

6. Font (9, p. 44); Kino (8, Vol. 1, p. 171; Vol. 2, p. 267); Velarde (79, pp. 129; 132); Oñate (32, p. 167); Sedelmaier (2, pp. 111-112).

(62, p. 211). Mr. F. H. Douglas says that the older people at Acoma still remember the cultivation of cotton for textile purposes. In 1934, Dr. Leslie A. White found cotton being grown at Santa Ana for ceremonial purposes. It would not be surprising if some of the other more conservative pueblos of the region are still growing a small amount of cotton.

Mrs. Stevenson reports that the Zuni made cotton textiles as late as 1879, (73, p. 77) and in 1910 were using native cotton for ceremonial purposes (73, p. 92). In 1916, Spier (70, p. 64) collected notes on the former cultivation, ginning, and spinning of cotton from a Zuni informant. These operations, however, had been performed in the childhood of the informant, then a woman sixty years old. Recent accounts state that cotton is still used ceremonially at Zuni.

Ten Broek states that the Hopi grew cotton in 1851 (67, p. 171). Ives (43, p. 127) reported in 1861 that the Hopi were growing cotton in small quantities. In 1890, cloth from traders was diminishing the amount of cotton woven into textiles (67, p. 184). Between 1895 and 1910, several lots of cotton seed were collected from Moencopi and Oraibi and were grown experimentally (49, pp. 6-8). Cultivation has declined and may now be extinct there, but as recently as 1932, seeds claimed to be from the current crop at Moencopi were obtained from a Hopi at Oraibi. Several individuals and institutions are still growing cotton from Hopi seed. Aboriginal cotton was demanded for ceremonial purposes and for some textiles until recently, but now commercial cotton is acceptable. The Hopi have continued their weaving to a greater extent than the other pueblos and have supplied ceremonial garments to other pueblos in recent years (14, p. 1).

Spier (71, p. 105) reported that in 1921 the Havasupai were growing cotton from seed obtained from the Hopi. The lint was used in the strike-a-light, but they made no cotton textiles.

Bartlett (4, pp. 223-229), Emory (18, pp. 83-85) and Whipple (76, pp. 598-599) reported that considerable cotton was grown and used by the Pima at about 1850. Whipple (76, p. 598) also claims to have seen an Apache cotton field near the Gila. Cotton seed from other regions was distributed among the Pima in 1864 (69, p. 77), and cotton has been grown commercially in the region for years. The culture of the aboriginal product had so nearly died out in 1901-1902 that sufficient cotton of Pima raising to weave a small fabric was "secured with difficulty" (69, p. 148). Hrdlicka, in 1905, reported (41, p. 361) that the Maricopa had not grown cotton for forty years. Spier, in 1932 (72, pp. 110-122), took notes on the Maricopa method of weaving, which was still well known, but no aboriginal cotton could be found (72, p. 113). Castetter and Underhill, in 1935 (13, p. 37), reported that Papago

informants were of the opinion that cotton had been cultivated formerly, but was no longer grown.

Lewton (49, p. 8) mentions a specimen of cotton collected from the Pima at Sacaton by Mr. E. W. Hudson. Dr. T. H. Kearney (correspondence, April 13, 1936) states that little of the history of this specimen is known, other than that it was obtained from the Pima and that the strain has been kept alive to the present by annual plantings at the U. S. Field Station at Sacaton.

Evidences of cotton have come from various archaeological sites in the Southwest. Direct evidence of its prehistoric cultivation and use consists of lint, seeds, bolls, fragments of plants, and cotton fabrics and cordage. Indirect evidence is found in the form of spindles, weaving implements, looms, and their fragments. Such material is fairly abundant and comes from a much larger area than is represented in historical and ethnological accounts.

Archaeological specimens of cotton from the Rio Grande region are not numerous. Specimens from Fríjoles Canyon, Puye, Unshagí, and Jemez Cave are in the Museum of New Mexico at Santa Fe. Recent field work of the University of New Mexico has produced indications of cotton from Kuaua, Puaray, and from the Estancia Basín.<sup>7</sup> Cotton fabrics and spinning and weaving implements, although present, were comparatively rare at Pecos (47, pp. 225; 292; 301-302).

Evidences of cotton are plentiful in the San Juan region, but even there cotton appears to have been secondary to other textile and cordage materials and was often used in conjunction with them. Discoveries of seeds and bolls have been considered as indicating its cultivation in that area (48, pp. 112-114; 59, pp. 94 and 104; 63, p. 107). Cotton has been found in such sites as Betatakin (45, p. 63), Pueblo Bonito (63, pp. 96-97; 107; 146; 157), Chetro Kett (correspondence, Paul Reiter), Aztec (57, pp. 47-48; 58, p. 223), and several of the cliff-dwellings of the Mesa Verde (59, pp. 94 and 104; 22, p. 45; 23, p. 76).

In the northwestern peripheral region, cotton has been found in Gypsum Cave (36, p. 160; 195) and elsewhere in Nevada (34, p. 273), and even in the San Joaquin Valley of California (29, p. 104). These finds have usually been considered as intrusive, but the abundance of such material in sites in the Moapa Valley of Southern Nevada gives rise to the opinion that cotton may have been cultivated there (35, p. 11).

Evidences of cotton have come from Awatobi (21, pp. 626-630), Kawaiokuh (38, p. 341; 345), and a site in the San Francisco Moun-

7. Correspondence, Paul Reiter, Curator, March 17, 1936.

8. Correspondence, Dr. Donald Brand, Department of Anthropology, January 6, 1936.

tains (3, pp. 46-47). The Museum of Northern Arizona has a fine series of cotton textiles from Wupatki. Valuable finds of textiles and spun cotton have been made in the Canyon del Muerto (1, p. 25).

Cotton has been found in the Rio Verde (1, pp. 65-66; 21, p. 573) and Sierra Ancha (37, pp. 83; 87-101) regions of Arizona. Along the Gila, it is reported from Casa Grande (24, pp. 147-148), the Grewe Site,<sup>9</sup> and McEwen Cave,<sup>10</sup> and perhaps elsewhere. Early excavations in the upper Gila region produced considerable cotton material (40, p. 9). Evidence of cotton is scarce in the Mimbres area and it is considered intrusive (16, pp. 3; 67).

At the present stage of archaeological investigation in the Southwest it is not possible to date the time of entry of cotton into the different regions. Basket Maker sites have produced no conclusive evidence of cotton.<sup>11</sup> The work of Kidder and Guernsey in the Kayenta region,<sup>12</sup> seems to establish the simultaneous appearance of cotton, the spindle and the loom there at about Pueblo I times. Woodward recently discovered cotton seed and what appear to be impressions of cotton textiles in a Colonial Hohokam site.<sup>13</sup> So far, evidence for an earlier introduction of cotton is lacking. Doubtless future work will give more specific information.

A number of specimens of cotton from archaeological sites and evidence of its aboriginal cultivation in the Southwest have come to the attention of botanists. A new species, *Gossypium hopi*, was described by Lewton in 1912 (49) from plants grown from seed collected at Oraibi and Moencopi early in this century. He examined two other specimens which he considered belonged to this species. One was collected by Mrs. Stevenson near Española, New Mexico, and one from the Pima at Sacaton (49, p. 8). Specimens since identified as of this species are one from the Havasupai (71, p. 105), and lint from Gypsum Cave (36, p. 195). Material collected in the Southwest and identified previous to the publication of Lewton's species, and not mentioned by him, are: Bolls from southeastern Utah identified as *Gossypium aboriginum* (63, p. 107), a species not recognized in botanical literature; and a specimen from the Zuñi which was identified as *Gossypium hirsutum* (73, pp. 77-78; 92). On re-examination these might be included in Lewton's new species.

Plants grown from Hopi seed were assigned by the English botanist Watt to the species *Gossypium punctatum* (75, p. 169; 181).

9. Correspondence, Arthur Woodward, Los Angeles Museum, March 10, 1936.

10. Verbal account by Dr. Byron Cummings, University of Arizona.

11. See Kidder and Guernsey (48, p. 171) for statement concerning reported Basket Maker cotton.

12. Guernsey (30), Guernsey and Kidder (31), Kidder and Guernsey (48).

13. Correspondence, Arthur Woodward, March 10, 1936.

These doubtless belong in *Gossypium hopi*, as plants grown from the same lot of seeds were used by Lewton in describing the new species (49, p. 10).

The plant which was collected by Dr. White at Santa Ana was sent to Lewton for examination. He considered it somewhat different from type material of *Gossypium hopi* (correspondence, February 8, 1936). Additional plants are being grown at the U. S. Field Station at Sacaton during the present season. A study of these should determine whether the differences are varietal or specific.

There is, thus, not a specimen of aboriginal cotton from the Southwest which unquestionably is of any species other than *Gossypium hopi*. It appears, therefore, that only one species existed there in prehistoric times. The possibility that the Santa Ana, Pima, and Española cotton might all have been obtained from the Hopi within recent years is not overlooked. It is realized that there is active exchange of seed between the Southwestern tribes. However, the case for a single species will depend largely on archaeological evidence when and if satisfactory identifications of archaeological cotton are made.

*Gossypium hopi* is of the Mexican-Central American sub-group of cotton which had its origin in the region for which named.<sup>14</sup> This sub-group contains the American Upland cottons, typified by *Gossypium hirsutum*, the species commonly grown in the Southern cotton-belt. *Gossypium hopi* and *Gossypium hirsutum* hybridize readily, but there is sufficient segregation of characters in the second generation to indicate that the relationship is not close.

It has been suggested that Southwestern cotton might have been domesticated within the region and might have had the Arizona Wild Cotton *Thurberia thespesioides*, as an ancestor. There are several serious obstacles to this theory. "Wild Cotton" is a misleading name for this plant, which is not a true cotton, but a member of a related genus. The number of chromosomes of Wild Cotton and Hopi cotton differs and the relationship in general is not close. There are no wild species of cotton in the Southwest and *Gossypium hopi* has been found only in Indian cultivation.

Cotton is a perennial plant in its native habitat in the tropics. In the temperate zone it is commonly cultivated as an annual. The season in the Southern cotton-belt is ordinarily from 150-180 days. Hopi cotton, in contrast to this, is adapted to an extremely short season, maturing in 84-100 days (49, pp. 7-8). It has a shorter season than any other cotton yet reported and has been used in Egypt in hybridization work to produce early varieties. (49, p. 7-8, '75, p. 182). Cotton is usually cultivated south of the thirty-fifth parallel at low altitudes,

14. This discussion of the affiliations and origin of Hopi cotton is based chiefly on Kearney (46) and correspondence with Kearney, winter and spring, 1936.

but because of its short season of maturity *Gossypium hopi* was successfully grown by the Hopi at about thirty-six degrees latitude at high altitude. This species could have been and may have been grown formerly in southern Utah and Colorado. Hopi cotton has been grown at Ann Arbor, Michigan, at latitude of forty-two degrees, and while not vigorous, it produced seeds and lint.

Indications are that the cultivation of cotton in the Old World previous to the tenth century and elsewhere in this hemisphere, except perhaps in Peru, was confined to the tropics and based on perennial cottons (75, pp. 9-16; 33, pp. 17-26). It appears that the Southwestern Indians may have been the first people to grow cotton as an annual. In any event, the adaptation of a tropical perennial plant to a season of less than one hundred days is a remarkable achievement.

Hopi cotton is distinct from all other cottons in several of its characteristics.<sup>15</sup> Fragments of plants from archaeological sites can be identified with a reasonable amount of assurance. The lint is particularly distinctive, having the unique combination of fineness of fiber and shortness of staple length.<sup>16</sup> This feature offers a very promising approach as so much of the available archaeological material is in the form of textiles, cordage, and lint.

The utilization of fiber measurements in identifying archaeological specimens of cotton is not new. Means (52, pp. 454-455) examined textiles from sites in Peru and concluded that of three or more species of cotton available there, only one was used in the ancient textile art. Fiber from Mohenjo-Daro, India, has been examined and found to be almost identical with that of a species cultivated in India today (46, p. 197).

This method has been used to a limited extent in the Southwest. Lint from Gypsum Cave has been identified as of *Gossypium hopi* (36, p. 195), but the technique used has not been reported. Cotton yarn from a spindle from the Canyon Creek Ruin (dates 1326-1348) was compared to *Gossypium hopi*<sup>17</sup> and found to have a mean fiber length of .88 inch while *Gossypium hopi* had a mean of .81 inch. As much difference may be found in fiber from different bolls of the same plant. The array of different fiber lengths gave almost identical curves for the two. Naturally, this does not constitute an identification as to species, but as *Gossypium hopi* has a fiber length distinct from other cottons

15. For a description and illustrations of Hopi cotton, see Lewton (49, pp. 8-10).  
16. It may be of interest to note that because of its peculiar combination of shortness and fineness of staple, Hopi cotton is being used by the U. S. Department of Agriculture at present, in breeding experiments to produce a cotton with fine fiber of medium length. If these experiments are successful the quality of American commercial cottons will be greatly enhanced.

17. From report of Mr. H. J. Fulton, U. S. Field Station, Sacaton, Arizona to Dr. Emil Haury, Gila Pueblo, November 14, 1935.

growing today, and as the archaeological specimen compares so closely, the similarity is highly suggestive. Similar measurements of archaeological specimens from other areas and culture horizons of the Southwest would be most interesting.

Data on the manner of cultivation, harvesting, ginning, carding, and spinning of cotton in the Southwest are very scanty. The cultivation and use of aboriginal cotton by Indians were practically extinct when anthropological work was begun in the region, and little is available in anthropological literature. The historical accounts are, as a rule, very general.

Spier (70, p. 64) gives in some detail the method of cultivation and treatment formerly practiced by the Zuñi. Planting took place in irrigated gardens in July. The seeds were placed in holes one and a half inches deep and covered with white sand. Dirt borders were placed about the plants to facilitate watering by hand. The plants were watered three days and then received no water for three days, this alternation continuing until September, when the cotton was harvested. The plants received no further cultivation or attention. The bolls were harvested, broken open, and the seeds and sand removed by hand. The imperfect fibers were removed and the remainder straightened somewhat with the fingers. Carding was done with commercial wool cards. Spinning and weaving was done just as with wool today.

The indications are that the cultivation and treatment as described above was essentially the same for the region, but varied in detail. Irrigation apparently was the rule but was not always practiced. Luxán (50, p. 101) tells of Espejo's party marching between the Hopi First and Second Mesas for two leagues, "one of them through cotton fields." This cotton must have been grown without irrigation as no means of watering such extensive plantings exist in the Hopi country. According to Lewton (49, p. 6) cotton was still grown at Oraibi under dry conditions at the beginning of this century. However, most of the cotton grown by the Hopi in recent years has been grown at Moencopi under irrigation. The Maricopa formerly grew cotton without true irrigation on over-flow along the Gila (72, p. 58; 61-62).

When the cotton boll matures it opens, exposing the lint which, along with the seeds, is easily removed. Harvesting is generally accomplished by picking the seeds and lint from the open bolls which are left on the plant. It is interesting to note, however, that this was not the custom among the Zuñi. Spier states that the "harvested cotton bolls were broken open," so apparently the bolls were removed from the plant before mature. This same method must have been practiced by the Pima, as Emory (18, p. 83) tells of seeing cotton stacked

for drying on top of sheds, and Russell (69, p. 150) states that the cotton was first dried and then separated from the pod (boll).

The Zuñi, according to Spier's account, ginned and straightened the cotton with the fingers preliminary to carding. Amsden (1, p. 11) says that the Hopi, until recently, placed the cotton between two blankets and beat it with a flail until the fibers adhered to the blankets and could be scraped into roves ready for spinning. Apparently both ginning and carding were accomplished in the single process. Flails, similar to the one illustrated by Amsden, have come from archaeological sites and may have been cotton beaters. Kidder and Guernsey (48, p. 120), however, consider these as beaters used in harvesting seeds.

According to Spier (72, p. 113) the Maricopa used a stick for beating cotton and removing the seeds. The Pima (69, p. 148), and Papago (13, p. 59) methods were similar to this. Both the Maricopa and Papago used the plucking bow, an introduced device,<sup>18</sup> in carding cotton.

The study of spinning and weaving is specialized and very detailed. No close study of Southwestern methods and techniques will be made here. Archaeological evidence suggests that the spindle and loom accompanied or followed cotton into the Southwest. This might be expected, for, as Amsden suggests (1, pp. 8-12) the bast and leaf fibers available in the region are poorly suited to spinning and loom weaving, whereas cotton and wool are readily adaptable.

The spindle and loom were used universally throughout the region in conjunction with cotton.<sup>19</sup> There were some variations in techniques of spinning and weaving, but the spindle and the loom were uniform in principle throughout the Southwest. The waist loom had a general distribution (1, pp. 23-24). All references to looms in the Gila region seem to indicate the horizontal loom.<sup>20</sup> The vertical loom seems to have been the type most generally used elsewhere in the Southwest, and Amsden (1, pp. 24-26) offers a good case for its origin within the area.

The cotton products of the loom varied in weave, pattern, form, size, and function. A description of these textiles offers a problem of some magnitude. Most of these were clothing, which, in recent years, has been worn for ceremonial occasions. Other ceremonial uses were on prayer sticks, masks, and reed pipes, and as burial offerings and raiment. Among the Havasupai, cotton was used only for the strike-a-light (71, p. 105). Such an artifact has been found in a site in the

<sup>18</sup>. For a description and history of the plucking bow in this hemisphere, see Spier (72, p. 113).

<sup>19</sup>. Forde (25, p. 126) observed an interesting exception to this. The Yuma obtained cotton from the Pima but instead of spinning it with the spindle, rolled it on the thigh under the palm of the hand as was their practice with bast fibers.

<sup>20</sup>. Bartlett (4, pp. 225-226), Emory (18, p. 83), Russell (69, pp. 150-151), Spier (72, p. 115), Forde (25, p. 126), Castetter (13, p. 60).